Spawn characteristics in *Adelomelon ferussacii* (Donovan, 1824) (Gastropoda: Volutidae) from southern Patagonia, Argentina

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ABSTRACT

South Ameriean volutids are very homogeneous with regard to their reproductive mode. These gastropods generally spawn egg capsules containing few eggs; the embryos feed on substanees contained in the intraeapsular fluid and hatch as erawling juveniles. *Adelomelon ferussacii* lives on subtidal mud or sandy bottoms, yet the egg capsules collected in San Julián, Santa Cruz, Argentina, were found on flat smooth subtidal rocks. The egg capsule is globose and hemispherieal, flexible, opaque-white, and the attachment base is wide, measuring between 15–30 mm in diameter. One to six eggs were recorded inside each egg eapsule. The embryonie development oeeurred in the interior of the eapsule and eight stages are described. Crawling juveniles, with shells measuring between 11.25–14.8 mm, were observed at the last stage before hatching. Also a gregarious spawning event is recorded for the first time in the South Ameriean volutes.

Additional keywords: Neogastropoda, egg eapsules, development, hatching size, gregarious spawning

INTRODUCTION

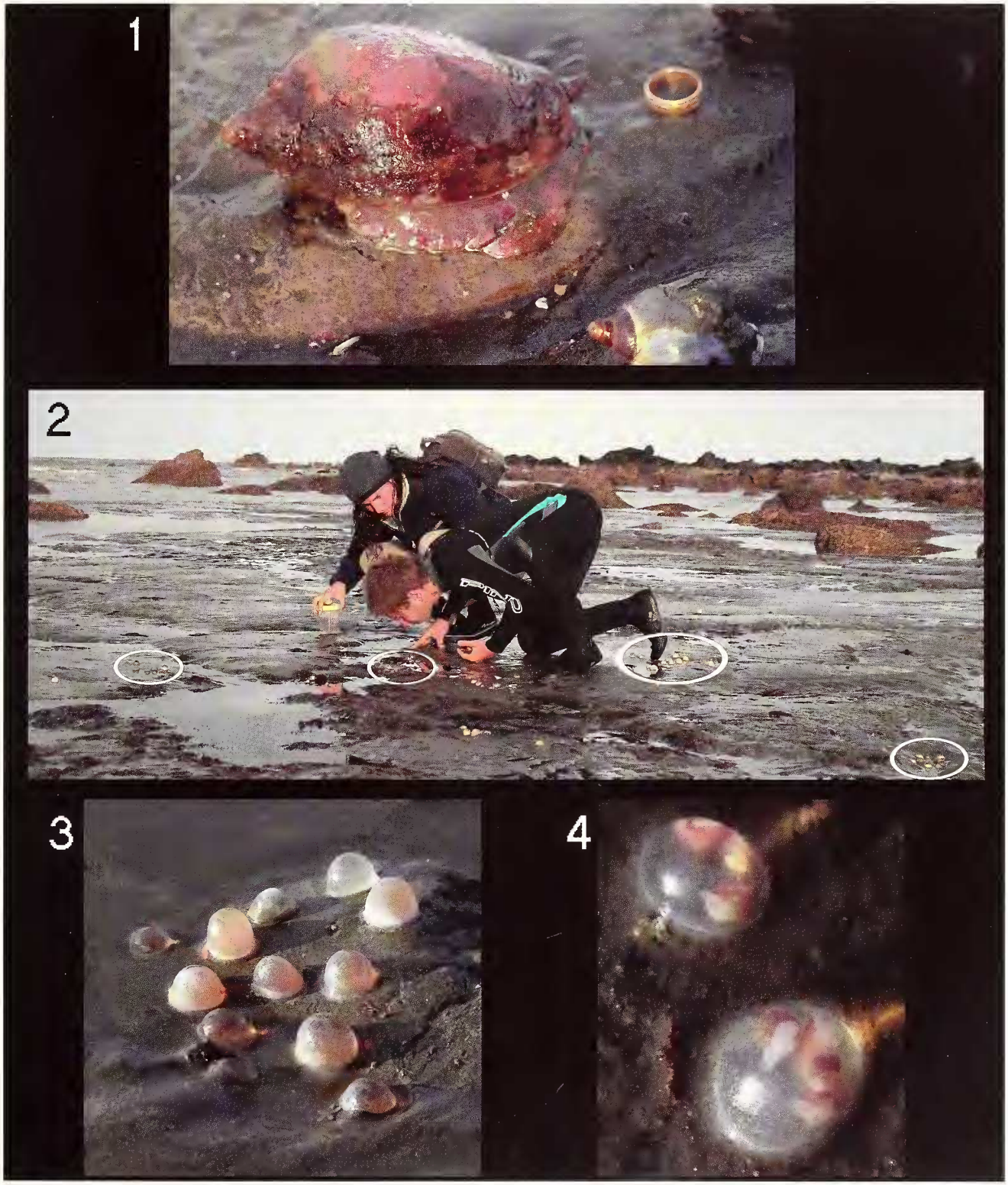
South American volutids are relatively homogenous with regard to their reproductive biology. Female volutes produce single, large egg capsules with relatively few eggs that are attached to hard substrates. Embryos develop until metamorphosis and hatch as crawling juveniles. Juveniles usually exceed 10 mm in total shell length, originating from eggs smaller than 300 µm that are suspended with extra-vitelline substances such as albumen in the intracapsular liquid (Penchaszadeh and De Mahieu, 1976). Yet, there are exceptions, sueh as *Voluta virescens* (Lightfoot, 1786), which is reported to spawn egg eapsules containing about 200 eggs. Of these, only one or two develop further, ingesting the others as nurse eggs (Bandel, 1976).

The spawnings of three species of the genus *Adelomelon* in the southwestern Atlantic have been described to date. *Adelomelon brasiliana* (Lamarck, 1811) has the largest known unattached caenogastropod egg capsules, with diameters between 40–80 mm and internal volumes of up to 140 ml (Penehaszadeh and De Mahieu, 1976). *Adelomelon ancilla* (Lightfoot, 1786) have oval and flat egg capsules, which are attaehed to hard substrates. The minor and major axes of their bases measure between 25–44 mm and 27–46 mm, respectively, and their internal volumes may reaeh four milliliters (Penchaszadeh et al., 1999). *Adelomelon beckii* (Broderip, 1836) have globose hemispherieal egg eapsules that are also attached to hard substrates, usually the external surfaees of empty seallop shells. Egg eapsules measure approximately 50 mm in basal diameter and have internal volumes between 30–35 ml (Penehaszadeh et al., 1999).

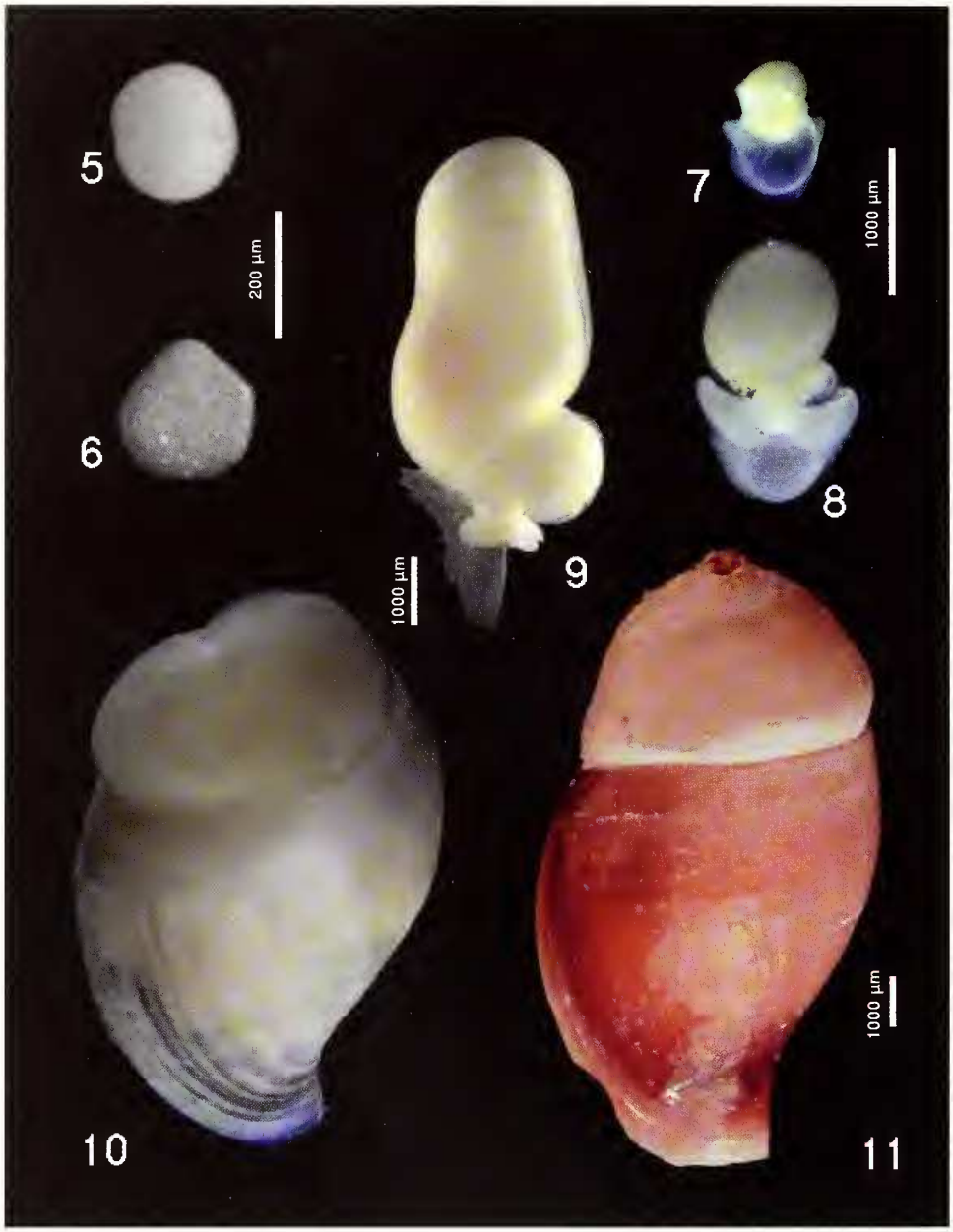
Adelomelon ferussacii (Donovan, 1824) are distributed from 42° S (Gulf San Matias) to 52° S (Straits of Magellan) (Careelles and Williamson, 1951), eorresponding to the Magellanie biogeographical province. Little is known about this speeies, whieh lives below the low water line on mud or sandy bottoms. This study deseribes the egg eapsules and the first stages of development of representatives of *A. ferussacii*.

MATERIALS AND METHODS

A total of 95 egg eapsules of *Adelomelon ferussacii* were colleeted during the austral summer by free-diving during low tides (2–3 m depth) at La Cascada in January 2005, and manually from areas exposed during an extraordinary low tide event in February 2006 at La Mina Beach, both loeated in San Julián, Santa Cruz Province (respectively 67°43′ W, 49°19′ S and 67°40′ W, 49°15′ S). The water temperature at the time of eollection was 15°C. Egg eapsules were collected from the roeky bottom by hand with the help of a spatula, preserved in individual jars in 70 % ethanol, and examined under dissecting and transmission optieal microseopes, as needed. The diameter and height of each egg capsule was measured using a Vernier ealiper, and each internal volume was measured by carefully extracting the intracapsular liquid with a Pasteur pipette. Egg eapsules were opened by eutting along their base line using a small surgical scissors. The number and stage of eaeh



Figures 1–4. Habitat and egg capsulues of *Adelomelon ferussacii*. **1.** Adult at low tide. **2.** Panoramic view of "Playa La Mina"; egg capsules of *A. ferussacii* are exposed during low tide. Circles indicate clusters of egg capsules. **3.** Detail of an egg capsule cluster. **4.** Egg capsules with juveniles close to hatching. Photographed by Natalie Collm.



Figures 5–11. Development of *Adelomelon ferussacii*. **5.** Uncleaved egg. **6.** Morula stage. **7.** First "veliger" stage. **8.** Second "veliger" stage. **9.** Late embryo without shell. **10.** Late embryo with calcified shell. **11.** Pre-juvenile close to hatching.

embryo was recorded and photographs of each stage were obtained through the mieroscope.

RESULTS

Spawning Sites: *Adelomelon ferussacii* (Figure 1) lays egg capsules on roeky bottoms. At La Cascada, where there is sandy-mud bottom, they were attached to flagstone slabs. At La Mina Beach, egg capsules were attached to the flat rocky bottom. Communal spawning was observed at both sites. The aggregation of spawning females results in a spawn cluster of more than 20 egg capsules (Figure 2), whieh indicates a gregarious behavior for spawning. Within the spawn eluster, individual egg eapsnles showed different developmental stages.

Characteristics of the Egg Capsule: The spawn consists of a single egg capsule attached to hard substrate, either a flagstone slab or another type of flat, roeky substrate. The egg capsule is globose, hemispherical and flexible, with a white opaque color (Figures 3, 4). It had a basal minor axis measuring 15–18 mm (N = 95), basal major axis measuring 29–31 mm (N = 95), and height of 11–21 mm (N = 95). The internal volume of egg capsules was 1.2–6.0 ml (N = 95) (Table 1). No exit plug or eseape aperture was observed in

Table 1. Dimensions of the egg capsule of *Adelomelon ferussacii*.

	N	Mean	Max.	Min.	SD
Diameter (mm)	95	21 × 23	29 × 31	15 × 18	2.30 × 2.52
Height (mm)	95	15.52	21	11	2.25
Int. volume (ml)	95	2.74	6	1.2	0.89

any capsule, only a suture line on one side of the capsules. The base is round with a narrow margin (~3 mm). No external calcareous layer was present.

Characteristics of the Early Developmental Stages: Out of the 95 egg capsules collected, only 61 contained embryos. The majority of the embryos were found in late developmental stages. Between one and six embryos per egg capsule were found, with a mode of three (mean = 2.8; SD = 1.1; N = 61) (Table 2). The following stages of development were identified: uncleaved egg; eight-cells; morula; "veliger I"; "veliger II"; late embryo without shell; late embryo with shell; and pre-juveniles close to hatching (Figures 5–11). The uncleaved egg diameter was 220 µm (N = 1), the eight-cell diameter was 220 µm (N = 1), the embryos in the morula stage measured 210–240 µm diameter (mean = 224 µm; N = 5). Those embryos in "veliger I" measured 750–950 µm in length (mean = 810 µm; N = 4); "veliger II" 1250–3500 µm in length (mean = 1860 µm; N = 21); embryos without shell 5–15 mm in length (mean = 8.3 mm; N = 98). The embryos presenting calcified shells ranged between 7.5–12.5 mm total shell length (mean = 9.7 mm; N = 34) and embryos close to hatching between 11.2–14.8 mm in total length (mean = 13.1 mm; N = 9) (Table 3).

DISCUSSION

Information on the spawning of volutids is scarce not only for South American species, but also for those from other regions of the world. As a general rule, South American volutids show little variation with regard to their reproductive patterns. Commonly, the egg capsules are attached to hard substrates; the fact that *Adelomelon brasiliana* spawns free eggs capsules is a remarkable adaptation to shallow sandy bottoms, given that they may

Table 2. Frequency of number of embryos per egg capsule in *Adelomelon ferussacii* collected in January 2005 and February 2006 in "La Cascada" and "La Mina" beach, San Julian, Argentina (N = 95).

N° embryos	Frequency
0	34
1	7
2	15
3	24
4	12
5	2
6	1
more	0

Table 3. Size at different stages of development identified for *Adelomelon ferussacii*.

Stages	n	Mean
Uncleaved egg	1	220 µm
8 cells	1	220 µm
Morula	5	224 µm
Veliger I	4	0.8 mm
Veliger II	21	1.8 mm
Embryo without shell	98	8.3 mm
Embryo with shell	34	9.7 mm
Close to hatching	9	13.0 mm

be carried away by the currents but are never buried in the sand (Penchaszadeh and De Mahieu, 1976).

Adelomelon ferussacii lives in shallow water, on mixed or soft bottoms along the Magellanic biogeographical province. The only available information on this species is based on very few specimens and mainly on shell features (e.g., Clench and Turner, 1964; Weaver and du Pont, 1970). As with all the other studied South American volutids, except for a single report on *Voluta virescens* (Bandel, 1976), *Adelomelon ferussacii* spawns egg capsules containing few eggs. The embryos feed on substances contained in the intracapsular fluid. Development is direct (intracapsular metamorphosis) and crawling hatchlings may have a shell length of more than 10 mm (Carcelles, 1944; De Mahieu et al., 1974; Penchaszadeh and De Mahieu, 1976; Penchaszadeh, 1988; Hain, 1992; Penchaszadeh et al., 1999).

The diameter of the eggs of *Adelomelon ferussacii*, including the uncleaved egg, eight-cells and morula stages, is about 220 µm. This size is smaller than the egg sizes reported for *Voluta musica* Linnaeus, 1758 (330 µm) (Penchaszadeh and Miloslavich, 2001). However, the egg size we measured is similar to those sizes reported for *Adelomelon brasiliana* (Lamarck, 1811) (240 µm), *A. ancilla* (Lightfoot, 1786) (200–220 µm) (Penchaszadeh and De Mahieu, 1976), and *Odontocymbiola magellanica* (Gmelin, 1791) (210 µm) (Bigatti, 2005), but larger than those of *Zidona dufresnei* (Donovan, 1823) (90 µm) (Penchaszadeh and de Mahieu, 1976).

The embryological development is similar to those described for *A. brasiliana* and *A. ancilla* by Penchaszadeh and de Mahieu (1976), with presence of a poorly developed velum. This contrasts with *Voluta musica* Linnaeus, 1758, which has a well-developed and wide intracapsular velum, the largest of the studied volutids (Penchaszadeh and Miloslavich, 2001).

Gastropod egg capsules are morphologically and chemically complex; they provide mostly protection against bacterial attacks, environmental stress, and predation (Pechenik 1979, 1986; Miloslavich 1996). Despite this, studies show that gastropod egg capsules are targets for predation by fish, crustaceans, polychaetes, and even other gastropods (D'Asaro, 1970). In this study, preyed-upon *Adelomelon ferussacii* egg capsules were observed. These were found lacerated mainly on their upper portions, probably by sea birds such as *Larus dominicanus* (Lich-

tenstein, 1823) and *Haematopus ater* Vieillot and Oudart, 1825, which were observed pecking on the egg capsules when these were exposed at low tides. Bird predation on volute stranded free egg capsules (*Adelomelon brasiliana*) was studied by Penchaszadeh et al. (2000).

Adelomelon ferussaeii egg capsules lack an external calcium carbonate cover such as found in the common Patagonian *Odontocymbiola magellanica* (see Bigatti, 2005); this would increase their susceptibility to predation.

Gregarious behavior was observed for the spawning of *A. ferussaeii*, as has been reported for several caenogastropod species such as *Engoniophos unicinctus* Say, 1825 (Miloslavich and Penchaszadeh, 1994), *Fusinus closter* Philippi, 1850 (Miloslavich and Penchaszadeh, 1997), and *Chicoreus margaritensis* (Abbott, 1958) (Cipriani, 1990). This conclusion is based on observations of presence of patches of egg capsules in different developmental stages along the shore. This is, to our knowledge, the first report of this behavior in the family Volutidae.

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